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Technology Evaluation of Retrieval Options for the Pit 9 Remediation Project

October 2003

Idaho National Engineering and Environmental Laboratory
Bechtel BWXT Idaho, LLC

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Idaho National Engineering and Environmental Laboratory
Idaho Completion Project
Idaho Falls, Idaho 83415

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Approved

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ABSTRACT

The mission of the Pit 9 Remediation Project is to implement the U.S. Department of Energy's approach for satisfying the interim remedial action obligation for a full-scale retrieval of Pit 9, as called for in the *Record of Decision: Declaration of Pit 9 at the Radioactive Waste Management Complex Subsurface Disposal Area at the Idaho National Engineering Laboratory,* and for achieving associated performance objectives that can be agreed on by the stakeholders. The *Pit 9 Record of Decision* addresses reduction of risk to the public and the environment posed by historical transuranic waste-disposal practices at Pit 9. Pit 9 is located in the Subsurface Disposal Area within the Radioactive Waste Management Complex at the Idaho National Engineering and Environmental Laboratory. The Pit 9 Remediation Project will be conducted as part of the Radioactive Waste Management Complex Clean/Close Project, which supports the larger Idaho Completion Project.

This report captures the first technology down-selection process used in the Pit 9 Stage III feasibility study for reviewing and evaluating options for retrieving waste material from Pit 9. This report describes the process and methodology followed to select the most promising alternatives through a value engineering process in accordance with U.S. Department of Energy Order 413.3, "Program and Project Management for the Acquisition of Capital Assets"; and then hrther refining those options using information developed during the start of the preconceptual design effort. The identified value engineering session established four possible options, which were then hrther refined down to three. The options were also categorized into above-grade or below-grade methodologies.

Above grade is where excavation equipment is located above the waste seam and waste is brought up from the digface, and below grade is where the excavation equipment is located on the floor of the pit with the digface in front of the excavation.

The three selected retrieval options use a large open primary and secondary confinement structure. These options are:

1. Backhoe and crane method—This option uses a backhoe to excavate the pit and an overhead crane to transport waste and soil to and from the pit.

2. Backhoe and front-end loader method—This option uses a backhoe and front-end loader to excavate the pit. The backhoe is used for selective excavation and the front-end loader is used for bulk removal and transporting of waste materials to and from the pit.

3. Backhoe and forklift method—This option uses a backhoe to excavate the pit and a forklift and automatic guided vehicle combination to transport waste and soil from the pit.

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ACRONYMS

AGV	automatic guided vehicle
D&D&D	deactivation, decontamination, and decommissioning
DOE	U.S. Department of Energy
EDF	engineering design file
FEL	front-end loader
INEEL	Idaho National Engineering and Environmental Laboratory
RFP	Rocky Flats Plant
RWMC	Radioactive Waste Management Complex
SDA	Subsurface Disposal Area
TRU	transuranic (e.g., radionuclide or waste)
VE	value engineering

Technology Evaluation of the Retrieval Options for the Pit 9 Remediation Project

1. INTRODUCTION

The mission of the Pit 9 Remediation Project is to (1) implement the approach established by the U.S. Department of Energy (DOE) for satisfying the interim remedial action obligation for a full-scale retrieval of Pit 9 within the Subsurface Disposal Area (SDA) at the Radioactive Waste Management Complex (RWMC) of the Idaho National Engineering and Environmental Laboratory (INEEL) and to (2) achieve associated performance objectives that can be agreed on by the stakeholders. This remedial action was called for in the *Record of Decision: Declaration of Pit 9 at the Radioactive Waste Management Complex Subsurface Disposal Area at the Idaho National Engineering Laboratory* (DOE-ID 1993). The *Pit 9 Record of Decision* (ROD) (DOE-ID 1993) addresses reduction of risk to the public and the environment posed by historical transuranic (TRU) waste disposal practices at Pit 9. The Pit 9 Remediation Project will be conducted as part of the RWMC Clean/Close Project, which supports the larger Idaho Completion Project. Figure 1 displays a map of the INEEL showing the location of the RWMC. Figure 2 shows a schematic of the RWMC with an expanded view of the Pit 9 area.

1.1 Purpose and Scope

This report captures the first technology down-select process used in the Pit 9 Remediation Project feasibility study for reviewing and evaluating options for retrieving waste material from Pit 9. This report describes the process and methodology followed to select the most promising alternatives through a value engineering (VE) process in accordance with DOE Order 413.3, "Program and Project Management for the Acquisition of Capital Assets," and then hrther refining those options using information developed during at the start of the preconceptual design effort. The identified VE session established four possible options, which were then refined to the three options outlined in this report.

Retrieval of Pit 9 waste will be performed in three basic layers: (1) overburden, (2) waste, and (3) underburden. Each layer will be handled separately, when possible, to minimize cross contamination Other activities taking place during retrieval include transferring waste to a sorting and characterization location, receiving waste that is acceptable for return to the pit, sampling remaining underburden, and replacing the removed underburden and overburden.

As shown on Figure 3, all of the selected options share the following three major processes:

1. Overburden removal—An approximate 1-m (3-ft) layer of overburden will be removed from the retrieval area and staged in a pile either inside or outside of the Pit 9 retrieval enclosure. The remaining, potentially contaminated overburden (approximately 1 m [3 ft]), will be removed and staged in a pile either inside the retrieval enclosure, or sent to characterization with the waste zone or before removal of the waste zone. The actual process will be refined later in the design effort.

2. Waste excavation—The waste zone will be excavated and delivered to a sorting and characterization location. The underburden will then be removed to the extent practical (assumed to be up to 0.6 m [2 ft]) and then sent to characterization with the remaining underburden being sampled for residual waste levels.

3. Pit closure—Finally, the underburden will be replaced with overburden (previously removed from the pit) and clean gravel to an approximate depth of 15 cm (6 in.). Acceptable waste from characterization and treatment will be returned to the pit in waste boxes. The remaining clean

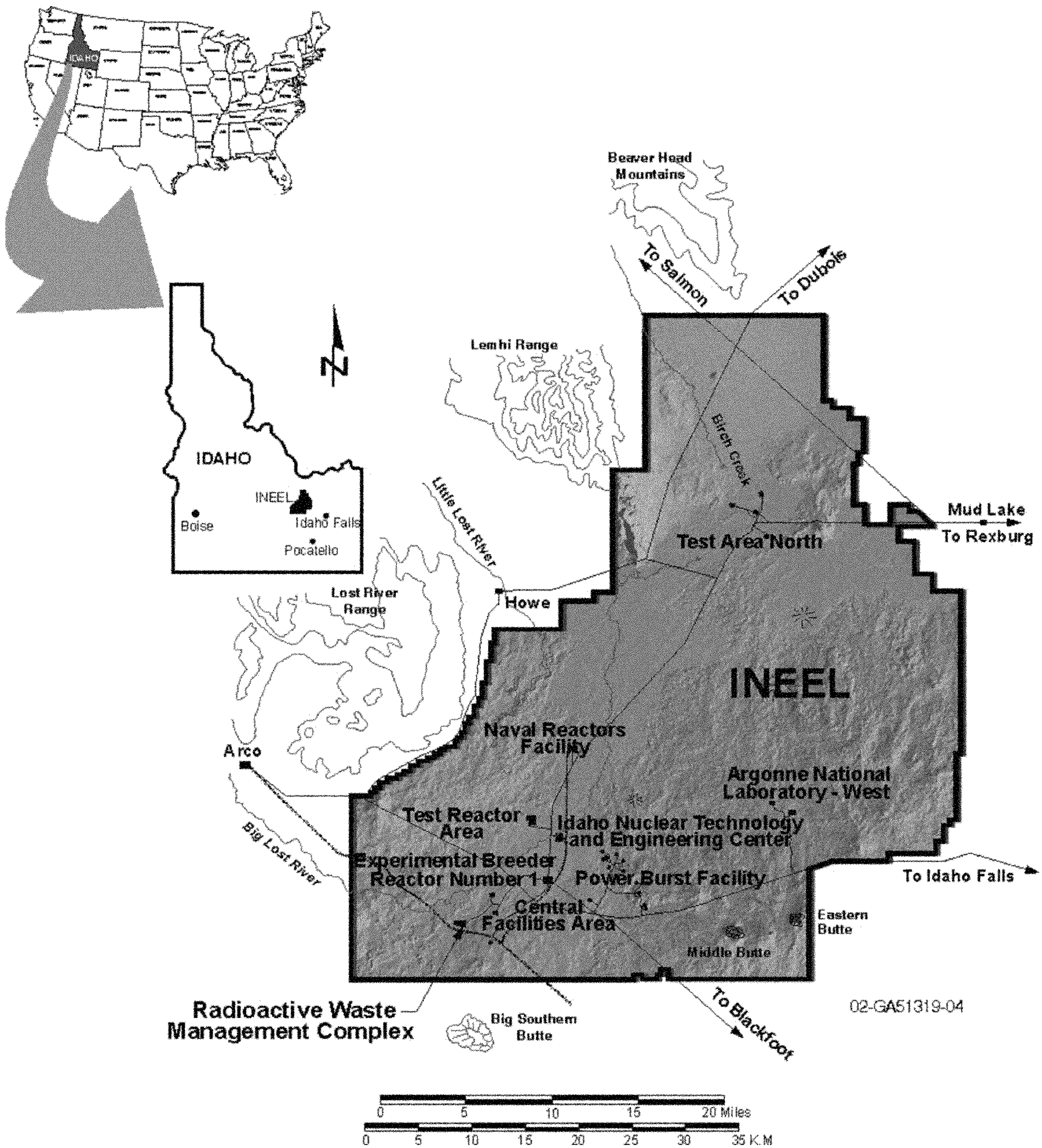

Figure 1. Map of the Idaho National Engineering and Environmental Laboratory showing the location of the Radioactive Waste Management Complex and other major Site facilities.

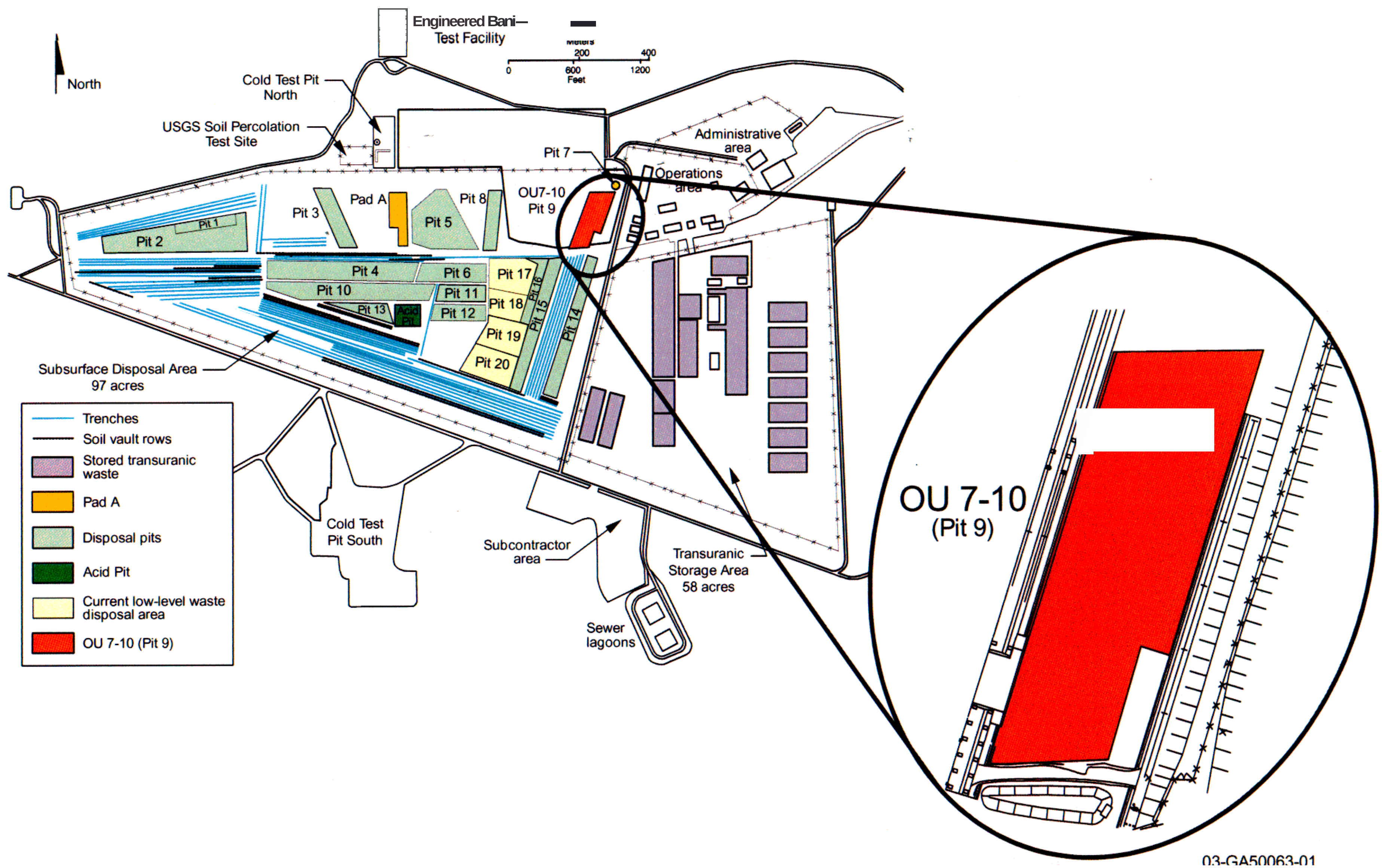

Figure 2. Map of the Subsurface Disposal Area showing an expanded view of the Pit 9 Remediation Project area.

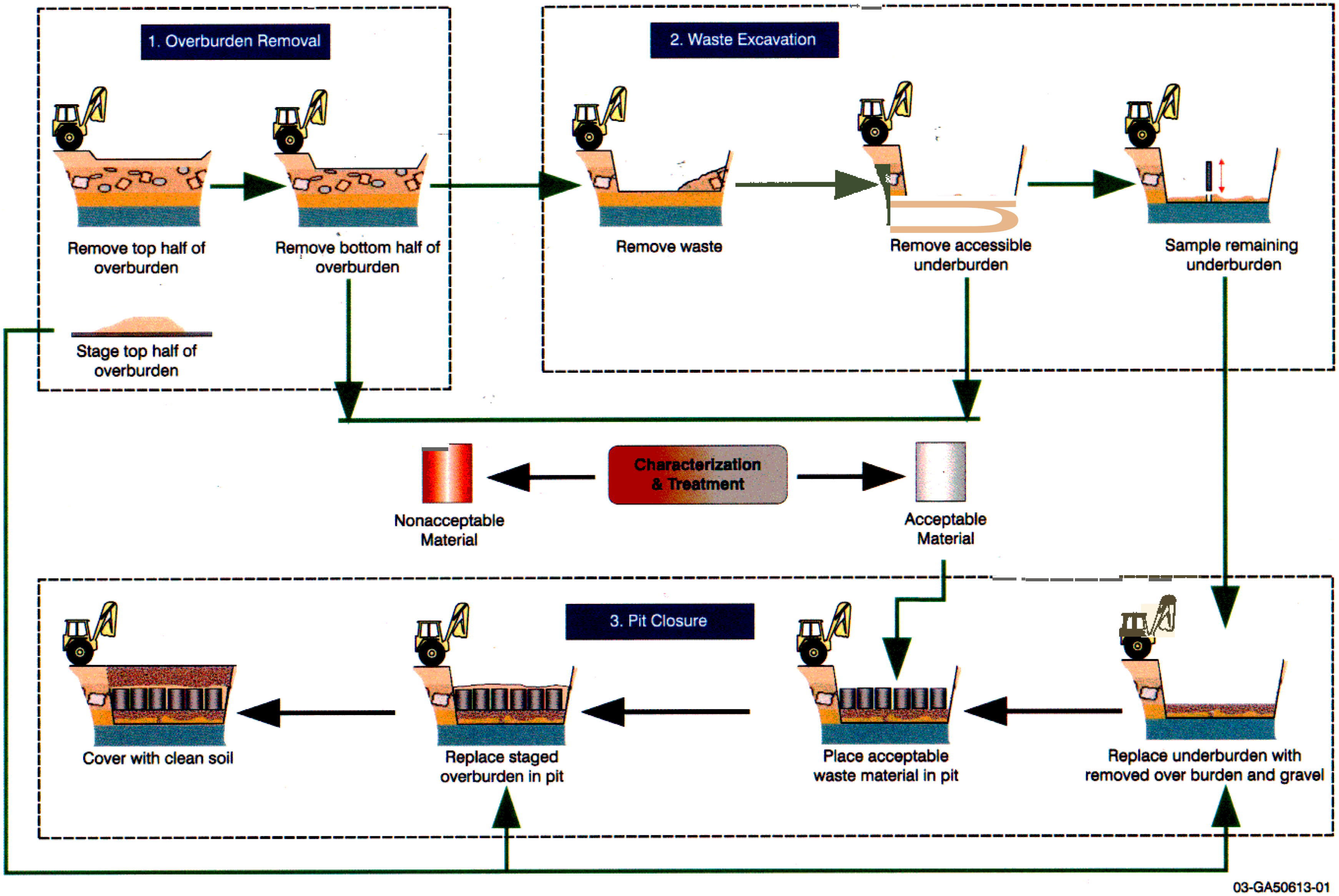

Figure 3. General excavation process.

overburden (i.e., can include characterized soil meeting predetermined return-to-the-pit criteria) will then be used to cover the waste boxes. Next, soil taken from an area outside the SDA will be placed in the pit, providing a clean soil overburden layer.

All retrieval options were categorized into two main areas as part of the VE session. The two categories are above-grade excavation and below-grade excavation. Above-grade methods attempt to minimize interaction of equipment to contaminated soil, while below-grade methods do not.

Three retrieval options were selected for hrther evaluation in the Pit 9 feasibility study. These three methods were selected based on cross contamination, contamination spread, implementability, and schedule risk. All three options use a large, open, primary confinement with a secondary confinement or weather enclosure and remotely operated equipment. The three options, identified variations included, are listed below:

- **Option 1 (above grade)—Backhoe and crane method:** This option uses a backhoe to excavate the pit and an overhead crane to transport the excavated material. During waste excavation, the backhoe loads waste into boxes, which are transported (by crane) to the transfer location. An automatic guided vehicle (AGV) transports the boxes from the transfer location to the characterization location. During pit closure, boxed waste meeting the criteria for return to pit are returned by the crane, and the soil is compacted by a remote compactor.

- **Option 2 (below grade)—Backhoe and front-end loader (FEL) method:** This option uses a backhoe to excavate the overburden and underburden and an FEL to excavate the waste zone. The FEL can also transport the excavated material to characterization or to an AGV, which then transports the soil to the characterization facility. The backhoe also assists the loader during waste excavation as needed. During pit closure, waste boxes are returned to the pit with a forklift and soil is returned and compacted by the loader. Boxes could also be used to return the characterized soil.

- **Option 3 (above grade)—Backhoe and forklift method:** This option uses a backhoe to excavate the pit into boxes and a forklift and AGV combination to transport the excavated material. During pit closure, materials are returned to the pit by the AGV and forklift combination and returned soil is compacted by a small compactor.

For all options, contamination spread will be minimized, possibly by using water sprays, water mists, dust-suppressant fogs, humidity control, temperature control, directed airflow, or filtration. Feasibility and applicability of these systems will require engineering design analysis and evaluation during the design phase. Mobile equipment will be operated slowly during excavation, dumping, and transport activities to minimize dust generation and spread. Actual operation speeds will be established during design.

1.2 Background

The INEEL is a DOE facility located 52 km (32 mi) west of Idaho Falls, Idaho, and occupies 2,305 km^2 (890 mi^2) of the northeastern portion of the eastern Snake River Plain. The RWMC is located in the southwestern portion of the INEEL as shown in Figure 1. The SDA is a 39-ha (97-acre) area located within the RWMC (see Figure 2). Waste Area Group 7, the designation for the RWMC as used in the *Federal Facility Agreement and Consent Order for the Idaho National Engineering Laboratory* (DOE-ID 1991), encompasses the SDA buried waste site.

Pit 9 is located in the northeast corner of the SDA as shown in Figure 2. The Pit 9 site is an area where chemicals, radioactive materials, and sludges from DOE weapons plants and other on- and off-Site government programs were buried. While such disposals at the RWMC began in 1952, Pit 9 was operated from 1967 through 1969. Pit 9 contains characteristic-hazardous, listed-hazardous, low-level-radioactive, and TRU waste.

Pit 9 does not lie in a floodplain. However, in 1969, local runoff from rapid spring thaws caused flooding that covered part of the SDA with water for a few days. During this flooding event, Pit 9 was partly open and meltwater filled the pit (see Figure 4). A dike has since been built around the SDA to prevent future flooding.

Two subsidence events at Pit 9 have occurred since pit closure. In 1985 and 1987, 9.9 and 0.06 m^3 (350 and 2 ft^3), respectively, of soil were added to the surface of Pit 9 to fill localized depressions. In both cases, soil placement occurred near the center of the pit.

Figure 4. 1969 Flood—view from the northeast corner of Pit 9 looking southwest.

1.3 Site Description

As shown in Figure 5, Pit 9 is approximately 38 m (125 ft) wide by 122 m (400 ft) long, with sheet piling, on both the east and west sides, driven to bedrock. The average overburden thickness is 1.8 m (6 ft), with a 1.8-m (6-ft) waste zone thickness and a 0.6 m (2.5 ft) underburden thickness. Actual thickness measurements for 80% of Pit 9 are not known, but are expected to be similar.

Approximately 7,100 m^3 (251,000 ft^3) of overburden soil and approximately 4,250 m^3 (150,000 ft^3) of packaged waste have been buried in Pit 9. Approximately 9,900 m^3 (350,000 ft^3) of soil is estimated to be distributed between and below the packaged waste when Pit 9 was closed.

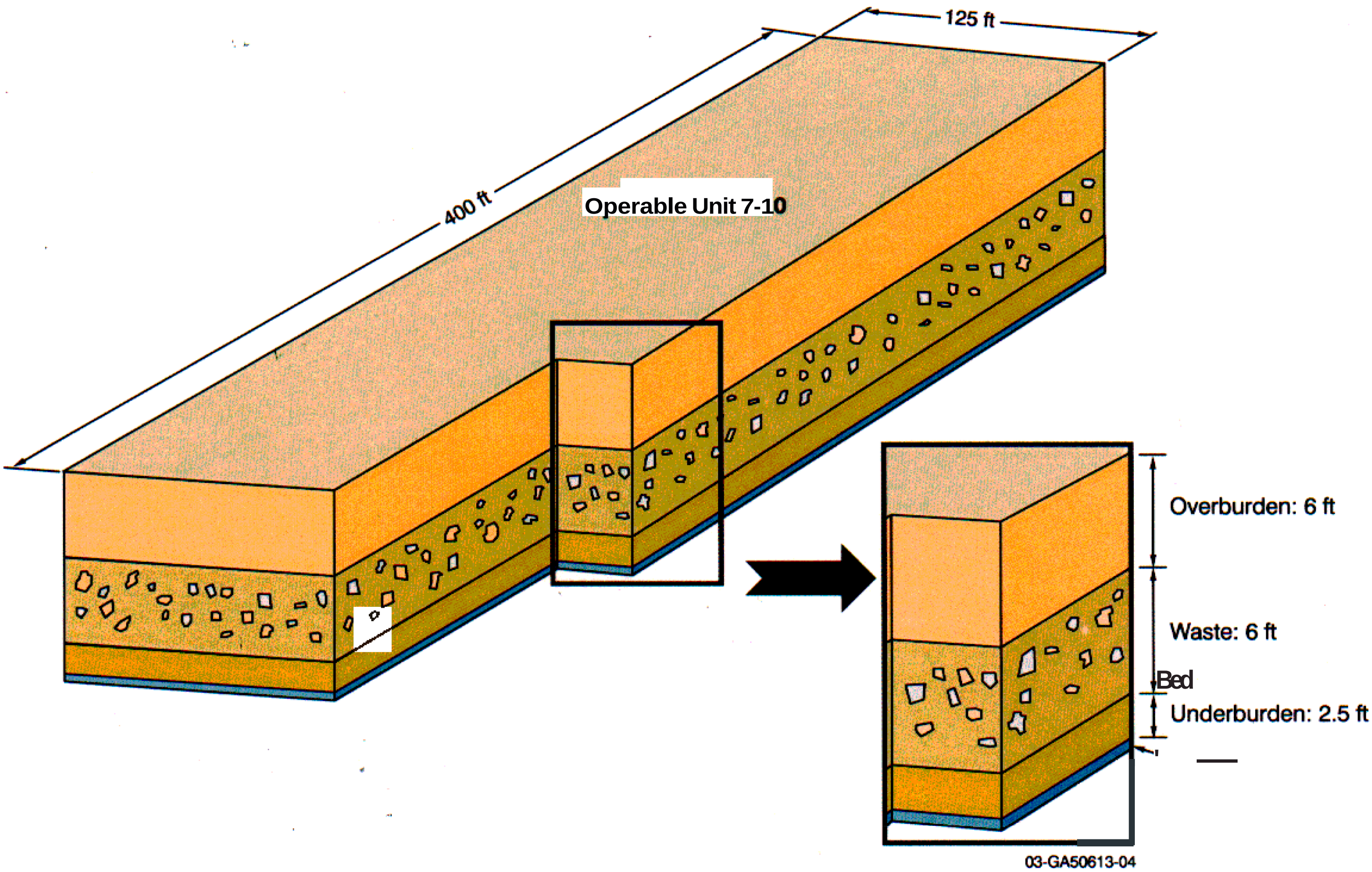

Figure 5. Cross-section of the Pit 9 area.

1.4 Waste Descrlptton

Waste materials from DOE weapons plants and other on- and off-INEEL government programs were buried in the Pit 9 disposal m a . Approximately 3,400 m^3 (120,000 ft^3) of the Rocky Flats Plant

(RFP) waste, containing large amounts of uranium and TRU radionuclides, and approximately 850 m^3 (30,000 ft') of non-TRU waste from INEEL were buried within the Pit 9 area. The waste has been categorized by general waste stream types including sludge, combustible and noncombustible debris, graphite, roaster oxide, beryllium, and filters.

Sludges were packaged in 55-gal drums. **A** few sludge drums were received from INEEL facilities, but most were received from the RFP. These sludges are referred to as Series 74 sludges and are identified by the building that generated them (i.e., Series 741, 742, 743, 744, and 745). The drums contained organic liquid waste, salt precipitate, complexing chemicals, and salt residue from evaporation ponds. The waste was double-bagged and mixed with cement or calcium silicate to absorb free liquid and to thicken or solidify the waste. Some of these sludge drums were relatively lightweight and were boxed in cardboard cartons. These drums are presumed to be empty, although contaminated from previous contents.

Combustible debris, consisting of paper, cloth, plastics, and wood, was packaged and delivered in 55-gal drums, cardboard boxes, or wooden boxes. Noncombustible debris, consisting of metal objects, was similarly packaged and often was mixed with the combustible debris. Noncombustible debris were, however, delivered unpackaged, on pallets or dumped directly from a truck or dumpster. Some large or heavy metal objects (e.g., reactor core, tanks, casks, and a pickup truck bed) were also placed inside the pit.

Graphite scraps, scarping, and fines were packaged in 55-gal drums, as were roaster oxides (uranium). Some debris drums are categorized as "Type Be," presumably inferring that some amount of beryllium was placed inside these drums.

Filters (e.g., high-efficiency particulate air filters, absolute filters, Chemical Warfare Service filters, and prefilters) were packaged in wooden boxes or cardboard cartons. When packaged in wooden boxes, they were often copackaged with noncombustible debris.

Boxes, cardboard cartons, and loose debris were generally buried in the northern half of the area, and drums were generally buried in the southern half, though intermingling of containers in the burial area did occur. The 1969 flooding in the open portion of the pit may have hrther intermingled the waste that floated (see Figure 4).

Radiation levels at the waste container surface were generally low enough to permit contact handling; however, records indicate that some shipments from INEEL generators may have had surface readings greater than 200 mR/hour. Other containers used shielding to reduce the surface readings to a level that allowed shipment.

Tables 1 and 2 summarize known numbers and types of containers, weights, and volumes of the waste stream categories. Container quantities and weights are only minimum values because some shipping and disposal records did not report either the container quantities or the weight. Volumes were recorded for all shipments; however, values may be high because it is unknown whether the reported volume was the actual waste volume or the volume of the container, which may not have been full.

Table 1. Summary of waste types, containers, weights, and volumes

Summary Category	Container and Waste Type	Count	Weight (lb)	Volume (ft^3)
Sludge drums	55-gal drums - Series 741 sludge	432	216,937	3,173
	55-gal drums - Series 742 sludge	197	93,406	1,449
	55-gal drums - Series 743 sludge	1,143	619,722	8,03
	55-gal drums - Series 744 sludge	42	19,089	308
	55-gal drums - Series 745 sludge	265	109,987	1,949
	55-gal drums - Series 617 sludge	9	—	67
Total		2,088	1,059,141	15,349
Specific interest	55-gal drums - graphite	149	23,970	1,095
	Wooden boxes - filters	38	40,700	4,416
	Cardboard boxes - filters	69	4,845	538
	55-gal drums -beryllium	5	898	37
	55-gal drums - roaster oxide	8	5,918	59
Total		269	76,331	6,145
Contained debris	55-gal drums - combustible debris	79	8,689	577
	Wooden boxes – combustible debris	108	180,600	20,507
	Cardboard boxes – combustible debris	219	6,050	2,628
	55-gal drums - metal debris	187	28,905	1,380
	Wooden boxes - metal debris	132	226,920	17,326
	Cardboard boxes - metal debris	12	5,065	112
	55-gal drums - mixed debris	1,465	255,619	11,057
	Wooden boxes - mixed debris	309	651,400	37,918
	Cardboard boxes - mixed debris	75	4,608	900
	55-gal drums, boxed - mixed debris	1,439	93,286	17,676
Total		4,025	1,461,214	110,082
Loose debris	Casks or tanks - metal debris	3	3,000	461
	Casks or tanks - mixed debris	1	6,000	54
	Pickup bed - metal debris	1	275	90
	Crates and pallets - metal debris	—	8,000	500
	Dumpsters - metal debris	—	81,900	2,635
	Dumpsters - mixed debris	—	4,000	16
	Loose debris or other - metal debris	—	295,100	14,186
	Loose debris or other - mixed debris	—	14,500	1,408
Total		5	412,775	19,350
Grand total		**>6,387**	**>3,009,461**	**150,926**

Table 2. Refined summary by container type, waste type, and generator site.

Container	Count	Weight	Volume
55-gal drums	3,981	1,383,140	29,554
55-gal drums, boxed	1,439	93,286	17,676
Cardboard boxes	375	20,640	4,178
Wooden boxes	587	1,099,620	80,167
Casks or tanks	4	9,000	515
Bed of pickup	1	275	90
Crates and pallets	—	8,000	500
Dumpsters	—	85,900	2,651
Loose debris or other	—	309,600	15,549
Total	>6,387	>3,009,461	150,926
Waste Type	**Count**	**Weight**	**Volume**
Sludge	2,088	1,059,141	15,349
Graphite	149	23,970	1,095
Filters	107	45,545	4,954
Beryllium	5	898	37
Roaster oxide	8	5,918	59
Combustible debris	406	195,339	23,712
Metal debris	>347	649,165	36,691
Mixed debris	>3,289	1,029,485	69,029
Total		>3,009,461	150,926
Off- or On-INEEL Site		**Weight**	**Volume**
Off-INEEL (RFP)		2,505,621	119,992
INEEL		503,840	30,933
Total		>3,009,461	150,926

INEEL = Idaho National Engineering and Environmental Laboratory
RFP = Rocky Flats Plant

2. EVALUATION AND DOWN-SELECTION PROCESS

For the process of retrieving waste from Pit 9, a multitude of potential equipment and methods were considered feasible. The scope of the Pit 9 Stage III feasibility study is to evaluate the options for retrieving waste from the pit and to recommend a final solution for conceptual design. The feasibility study for the retrieval process is being performed in three phases:

1. Technology search to review the large number of options available for waste retrieval equipment and facility design

2. Down-selection process to reduce the number of options to between three and six

3. More detailed design and evaluation of the remaining three to six options to select the final option to recommend for conceptual design.

The retrieval technology search is documented in an Engineering Design File (EDF) -4025, "Technology Search for the OU 7-10 Stage III Retrieval Process.""Engineers experienced in each technical area (i.e., confinement, excavation, transport, material handling, and contamination control) also performed an initial evaluation of each technology.

The second phase of the Pit 9 retrieval process feasibility study is documented in this report. This second phase pertains to the down-selection process used in selecting the most promising options for hrther design and evaluation in the next phase. The third and final phase of the project will include process designs, initial equipment selections, risk analyses, and cost estimates of the selected options, as well as the final evaluation process. The third phase will be documented in a separate report.

2.1 Objective of Down Selection

The objective of the down-selection phase documented in this report was to evaluate the options for retrieval of waste and to reduce those options to a smaller number (three to six). The remaining options would then be hrther developed as described above.

2.2 Down-Selection Process

The down-selection process was achieved through a combination of internal engineering design team evaluations and VE sessions, which included personnel from outside the design team.

The engineering design team first developed a large number of feasible options, set up the framework for group discussions, and evaluated and developed results from the group sessions. The VE sessions provided validation of the design team's research, additional options for consideration, and assistance with the down-selection task. With the large number of options and the need to keep a simplified view of each option, it was more effective for the engineering design team to use the VE sessions as an input to the final decision on down-selection rather than allowing the decision to be made in the VE session.

The down-selection process was divided into the following steps:

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a. OU 7-10 Stage III Project was the original named used for Stage III of the waste retrieval process now called the Pit 9 Remediation Project.

1. Preparation for evaluation process — A framework for retrieval option evaluation was prepared including the following:

   a. Major retrieval hnctions

   b. Retrieval assumptions

   c. Initial evaluation criteria

   d. Equipment and structure options from the technology search effort

2. Evaluation process

   a. Initial VE session — A brainstorming session was held at the beginning of the first VE session to obtain external input and validation of the design team options

   b. Subteam VE session — A smaller group from the design team performed an internal VE session to reduce the number of system options

   c. Final VE session — A second VE session with external members was held to rank the remaining system options

   d. Engineering design team final selection of process — The top-scoring options from the VE session were hrther developed and evaluated by the engineering design team, and the team finalized these options for hrther evaluation.

2.3 Preparation for Evaluation Process

Information necessary for the evaluation process by the design team and the larger VE session group included background information on the Pit 9 configuration and basic retrieval process, major retrieval hnctions, assumptions, and evaluation criteria.

The design team and the VE session team were presented with diagrams of the RWMC and summaries of the pit contents. These documents can be found in the letter from the session facilitator documenting the VE sessions.[b]

The basic retrieval process defined by the Pit 9 Remediation Project is shown in the block flow diagram in Figure 6. This diagram shows the overall process from sampling and removal of pit overburden to final closing of the pit. Included are steps for removing waste, returning waste from characterization and treatment, sampling the remaining underburden, and reestablishing the underburden floor and overburden layer.

2.3.1 Major Retrieval Functions

The design hnctions are defined in the “System Requirements Document for the Pit 9 Remediation Project.”‘ The following list represents the major retrieval hnctions used in the retrieval VE sessions:

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b. Lori Braase Letter to Brent Helm, August 27,2003, “Final Summary of the Pit 9 Stage III Retrieval Value Engineering Session,” INEEL, LAB-07-03,

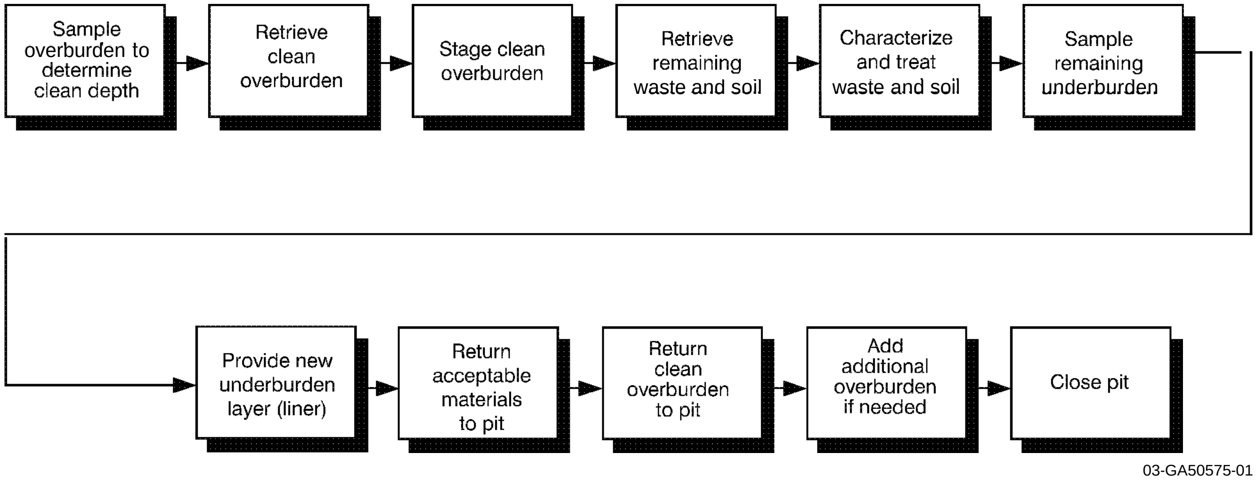

Figure 6. Block flow diagram of Pit 9 Remediation Project retrieval process

- Confine hazard
- Protect worker
- Retrieve waste and soil
- Remove and transport material to characterization
- Stabilize waste left in the pit
- Sample remaining materials in pit
- Install underburden floor
- Receive waste from characterization and treatment and return it to the pit
- Install clean overburden cover.

During the VE sessions, the hnctions considered most relevant in selecting equipment and facility options were to (1) confine hazards, (2) retrieve waste and soil, and (3) remove and transport material to and from characterization. Worker protection is considered an overlying requirement for all hnctions, and as such, was not considered a discriminator in the selection of equipment most suited to remote processes. All other hnctions were considered incidental in the higher-level decision of major equipment and facility type, but options were screened to ensure these hnctions could be adequately and reasonably addressed.

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c. INEEL, 2003, "System Requirements Document for the Pit 9 Remediation Project (Draft)," INEEL/EXT-02-01537, Rev. OB, INEEL.

2.3.2 Retrieval Assumptions

Assumptions used to evaluate potential retrieval processes for Pit 9 are discussed in the following subsections.

2.3.2.1 Project Definition Assumptions

- Waste outside the defined pit boundaries will not be retrieved.
- All Lockheed Martin Advanced Environmental Systems structures and equipment, except for the sheet piles, concrete, and rails, will be removed before Stage III construction begins.
- Pretreatment of contaminants before excavation is outside the scope of this project. This includes methods for dust control (e.g., in situ thermal desorption, in situ grouting with paraffin, and in situ vitrification).
- Hot-spot-retrieval scenarios less than 0.2 ha (1/2 acre) will not be considered for Stage III.
- Based on preliminary hazard evaluations, the primary retrieval confinement will be classified as a Hazard Class Safety Category II nuclear facility.
- Pit 7 (adjacent to Pit 9) will not be retrieved unless the Pit 7 waste falls within the boundaries of Pit 9.

2.3.2.2 Beginning Condition Assumptions. Original waste containers are significantly degraded.

2.3.2.3 Confinement Assumptions

- Retrieval of waste zone material will require a primary confinement system
- Retrieval of waste zone material will require a secondary enclosure that is a weather enclosure for the primary confinement. The secondary enclosure also may be required to function as a secondary confinement system.
- The retrieval primary confinement will withstand a design pressure of at least –1 in. (about 5 psf) of water and abnormal pressures as high as –4 in. of water (about 20 psf).
- Primary confinement material must be decontaminable, or contamination must be fixed before movement or demolition.
- Equipment will operate inside a controlled-environment enclosure with minimal human intervention.

2.3.2.4 Overburden and Underburden Assumptions

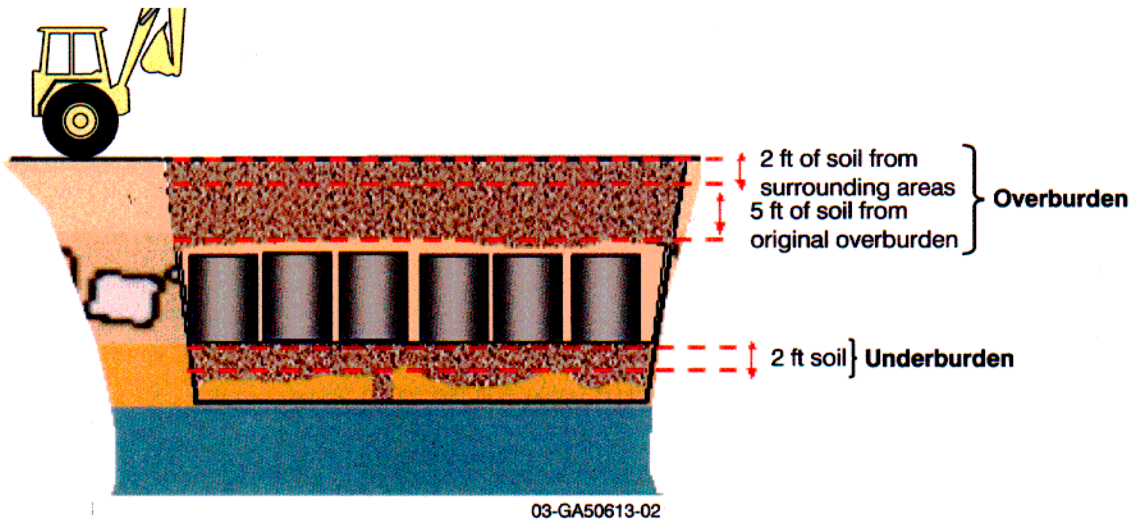
- Overburden:
    - Clean and slightly contaminated overburden will be removed first. The need to minimize contamination of clean soil outweighs the benefits of any options that contaminate the overburden. Some overburden will be removed as waste.

A minimum of (7 ft) of overburden is required in the pit after operations are completed, The top 0.6 m (2 ft) of this overburden will be clean material collected from surrounding areas such as the Spreading Areas. The lower 1.5 m (5 ft) may be original overburden from the pit with contamination levels at or below background (see Figure 7).

- Underburden:

  - Underburden is removed from the pit only to the extent practical. Remaining underburden will be sampled to determine the residual risk.

    A minimum of 0.6m (2 ft) of soil will be placed or left in the bottom of the pit after materials are returned to the pit. This soil may be semiclean or potentially contaminated (i.e., retrieved pit overburden or existing underburden, if verified acceptable). This requirement is waived for soil located under objects that are too large to move.



Note: The 0.6 m (2 ft) of soil from surrounding areas is clean soil from outside the Subsurface Disposal Area.

Figure 7, Overburden and underburden assumptions during pit closure.

2.3.2.5 *Operational Assumptions*

- With the appropriate personal protective equipment, entry will be possible for routine maintenance of equipment and monitoring devices.
- No classified material will be uncovered in the pit.
- Any containers retrieved intact will be sent to characterization.

- Manned operation of equipment will not adequately protect workers from potential retrieval operation hazards (e.g., radiological, chemical, fire, and explosion hazards).

- Retrieval rate will be 50 yd^3 per day.

- Retrieved waste will be delivered to a characterization building.

- Stage III retrieval will be a production excavation process. Speed of operations will be less than construction or mining operations to account for safety and contamination-spread issues. Speed of operations will not be slowed for mapping locations of waste.

- Maintaining a clean (i.e., radiologically uncontaminated) operating environment that would allow manned operation of equipment is impractical for Stage III. Allowing a dirty (i.e., radiologically contaminated) operating environment without concern over contamination levels would require remote maintenance of equipment and also is impractical. Therefore, equipment and operation will be designed to control the spread of contamination inside the primary confinement to the extent practical. Design considerations will be made for the maintenance of contaminated equipment. Operations will be as radiologically clean as practical.

- A combination of water misting, water sprays, humidity controls, dust suppressants, and spray-on fixatives (e.g., strippable paint) will be used to control dust generation. Careful operations at a reduced speed and directed airflow also will assist in contamination control.

2.3.2.6 *Waste Assumptions*

- High-radiation items exceeding 200 mR either will be left in the pit or returned to the pit after characterization.

- Stabilization of pit contents is not required for radiological issues. Stabilization is required only to prevent subsidence of the pit so that a cap may be applied in the future.

- Waste materials returned to the pit from characterization will be in boxes. Contaminated soil may be in boxes or sacks. Original overburden returned to the pit may be in boxes, bags, or loose.

- The amount of material returned to the pit will not exceed the capacity of the pit. This material will include (1) waste returned from characterization and treatment, (2) the required amount of underburden, and (3) the required amount of overburden soil.

- Large items (that do not fit in a 5 x 5 x 10-ft box) and high-radiation-field objects will remain in the pit. Possible objects in this category are truck beds and fuel rods. Sheet piling and rails will not be removed. Probes from the Pit 9 Remediation Project may also be left in the pit.

- Disposal of secondary waste (including deactivation, decontamination, and decommissioning [D&D&D] waste) in Pit 9 will be allowed only if the secondary waste meets the land disposal restrictions.

2.3.3 Initial Evaluation Criteria

The criteria used to evaluate the retrieval options were based on "Comprehensive Environment Response, Compensation, and Liability Act" (42 USC § 9601 et seq., 1980) evaluation criteria.

A detailed interpretation of the Comprehensive Environment Response, Compensation, and Liability Act criteria for the Pit 9 Stage III retrieval process is contained in Appendix A. This interpretation includes subcriteria and definitions of applicability to the Stage III retrieval process and the project requirement of potential applicability to other TRU burial pits and trenches within the SDA.

For the evaluation process described in this document, the criteria in Appendix A were simplified to reduce the number of criteria against which each option would need to be scored. A shorter list of criteria was considered more appropriate for alternative analysis at this early stage of the design process. The team determined that the following criteria were the largest discriminators between different retrieval options. Simplified criteria and definitions used in the down-selection process are listed below:

1. Cross-contamination of waste—ability to maintain waste integrity from the digface to the characterization area

2. Contamination spread—ability to prevent dust generation during operations; ability to maintain a relatively clean operating environment

3. Schedule risk—ability to meet the assumed schedule of 6 to 24 months of retrieval operations

4. Implementability—simplicity, constructability, reliability, maintainability, operability, flexibility, and technical maturity.

2.3.4 Equipment and Structure Options from the Technology Search Effort

Appendix B contains a list of feasible equipment for excavation and transport of pit material and the options for confinement structures that were provided to the VE session participants.

The complete retrieval system will include a confinement structure and supporting equipment and equipment to achieve the necessary retrieval and transport hnctions. The number of combinations of these equipment and facility types to comprise complete systems is extensive.

To manage the number of system options and to facilitate the initial design and evaluation process, only the major equipment and hnctions were considered. These included the confinement method, excavation equipment, transport equipment, and the type of excavation process. The excavation process generally can be viewed as either of the following:

- An above-grade process where excavation equipment is located above the waste seam and waste is brought up from the digface

- A below-grade process, where the excavation equipment is located on the floor of the pit, with the digface in front of the excavation.

These categories of excavation process, confinement structure, and excavation and transport equipment were used to organize retrieval system alternatives for the evaluation process. Figure 8 shows an example of system options organized in an option tree. In Figure 8, the highlighted option uses a backhoe and vacuum in a small, moveable, primary confinement structure inside a large, secondary, confinement structure.

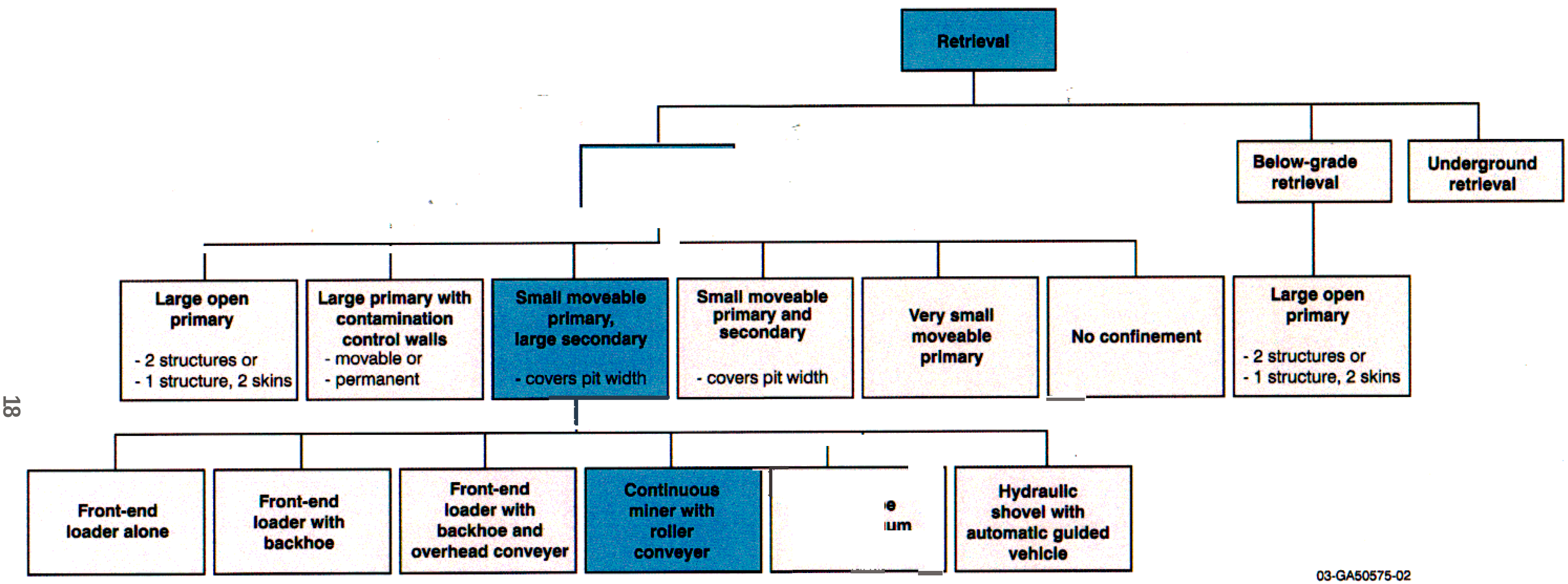


Figure 8. Option tree for retrieval system options.

2.4 Evaluation Process

Using the background information discussed above (including the major retrieval hnctions, retrieval assumptions, and the initial evaluation criteria) the engineering design team and VE session team developed and evaluated a large number of retrieval process and equipment options. Three final options were developed based on the options evaluated during the VE session. These three options will be hrther developed during the preconceptual design effort.

A structured VE process was followed, using a VE facilitator in accordance with DOE Order 413.3. Value engineering is an organized effort directed at analyzing hnctions to achieve the essential hnctions at the lowest life-cycle cost consistent with required performance, reliability, quality, and safety. These VE sessions are documented in a letter summarizing the Pit 9 Stage III retrieval VE (see footnote b).

2.4.1 Initial Value Engineering Session

The first VE session was held to initiate development and evaluation of retrieval system alternatives. Purposes of the meeting included:

- Identifying the full range of viable equipment, facility, and method alternatives using key hnctions of the retrieval process
- Eliminating the nonviable equipment, facility, and method options.

Results of this meeting included:

- Identifying 22 options for confining the hazard; five options were considered viable by the group. The identified confinement options are provided in Appendix C. The five options considered viable were:

  (1) Large, independent, primary and secondary structures over the entire pit

  (2) Large structure over the entire pit with primary and secondary skins on one structure

  (3) Large primary and secondary confinement with moveable, internal, rigid, and extendable contamination-control walls

  (4) Large primary and secondary confinement with permanent contamination-control walls and sheet piles through waste, matching permanent walls in the building

  (5) Small, moveable, primary confinement inside a large, secondary confinement building

- Identifying 60 equipment options for waste excavation and transport; 14f were considered viable by the group, depending on confinement type and excavation process. The identified equipment options are provided in Appendix C. The 14 waste excavation equipment options considered viable were:

  (1) Backhoe (mobile with wheels or tracks, or on rails)

  (2) Front-end loader (mobile with wheels or tracks, or on rails)

  (3) Excavator with FEL and backhoe (mobile with wheels, tracks, or on rails)

(4) Electric or hydraulic shovel

(5) Bobcat (smaller size)

(6) Overhead crane

(7) Hydraulic clamshell on a crane.

(8) Bobcat

(9) Forklifts (rough or smooth terrain)

(10) Excavation equipment or forklift with boxes, trays, or integrated transfer module

(11) Covered conveyors (e.g., belt, apron, monorail, roller, or slat)

(12) Overhead crane (with clamshell or grapple)

(13) Mobile crane

(14) Automatic guided vehicles.

2.4.2 Subteam Value Engineering Session

Because of the extensive number of possible alternatives remaining after the initial VE session, the decision was made to form a small subteam to hrther reduce the list of systems.

The subteam met during the week between the larger group VE meetings. This team combined the excavation process type (above grade or below grade) with the feasible confinement structure and equipment options to obtain a list of 92 feasible system options. Using a spreadsheet of the system options, the subteam evaluated the options against five criteria on a scale of one to five, with five being the best at satisfying each criterion. Criteria used were those discussed in Section 2.3.3, plus life-cycle cost. The tables of options and scores assigned by the subteam are provided in Appendix D.

This subteam evaluation reduced the list of system options to 19 for the final VE session. The 19 options are included in Table 3.

2.4.3 Final Value Engineering Session

In the final VE session, the group used a pair-wise comparison method to weigh the evaluation criteria. Weight given to the evaluation criteria are as follows:

- Cross contamination = 3%
- Contamination spread = 41%
- Life cycle cost = 0%
- Schedule risk = 15%
- Implementability = 41%.

Table 3. Evaluation table from value engineering subteam and final value engineering meetings

Facility Configuration	Alternatives				Criteria: Cross Contamination (0.03)		Contamination Spread (0.41)		Life Cycle Cost (0)		Schedule Risk (0.15)		Implementability (0.41)		Alt Total Score	Comments
		AG or BG	Excavation Equipment	Transport Equipment	Score	Subtotal	Score	Subtotal	Score	Subtotal	Score	Subtotal	Score	Subtotal		
Large, open, primary confinement with large secondary confinement	1	AG	Backhoe	FLor OH crane	3	0.09	5	2.05	0	0	10	1.5	10	4.1	7.74	Dumpintoabox.
	2	AG	Overhead crane	OHcrane	3	0.09	1	0.41	0	0	5	0.75	5	2.05	3.3	Dump into a box.
	3	BG	Hydraulic or electric shovel	FLor OH crane	6	0.18	3	1.23	0	0	10	1.5	6	2.46	5.37	Dump into a box.
	4	BG	FEL withbackhoe for support		10	0.3	8	3.28	0	0	10	1.5	8	3.28	8.36	—
Large, primary, confinement with moveable walls	5	AG	Backhoe	FLor OH crane	3	0.09	6	2.46	0	0	6	0.9	6	2.46	5.91	Dump into a box.
	6	AG	OHcrane	OHcrane	3	0.09	2	0.82	0	0	3	0.45	3	1.23	2.59	Dump into a box.
	7	BG	Shovel	FLorOH crane	6	0.18	4	1.64	0	0	6	0.9	4	1.64	4.36	Dump into a box.
	8	BG	FEL withbackhoe for support		10	0.3	10	4.1	0	0	6	0.9	5	2.05	7.35	—
Large, primary, confinement with two permanent walls	9	AG	Backhoe	FL or OH crane	3	0.09	7	2.87	0	0	8	1.2	8	3.28	7.44	Dump into a box.
	10	AG	OH crane	OH crane	3	0.09	3	1.23	0	0	5	0.75	4	1.64	3.71	Dump into a box.
	11	BG	Shovel	FLorOH crane	6	0.18	5	2.05	0	0	8	1.2	4	1.64	5.07	Dump into a box.
	12	BG	FEL with backhoe for support		—	—	—	—	—	—	—	—	—	—	—	Cross contamination. Size. Hard to transport waste with mobile equipment through permanent walls.

Table 3. (continued).

Facility Configuration	Alternatives				Criteria: Cross Contamination (0.03)		Contamination Spread (0.41)		Life Cycle Cost (0)		Schedule Risk (0.15)		Implementability (0.41)		Alt Total Score	Comments
		AG or BG	Excavation Equipment	Transport Equipment	Score	Subtotal	Score	Subtotal	Score	Subtotal	Score	Subtotal	Score	Subtotal		
Large, primary, confinement with several permanent walls	13	AG	Backhoe	FL or OH crane	—	—	—	—	—	—	—	—	—	—	—	Variations of alternatives 9 and 10, but less practical due to space constraints resulting from the necessity for two cranes in each confinement area.
	14	AG	OHcrane	OHcrane	—	—	—	—	—	—	—	—	—	—	—	
Small, moveable, primary confinement with large secondary	15	AG	Backhoe	FLorOH crane	3	0.09	6	2.46	0	0	2	0.3	2	0.82	3.67	Dump into a box
	16	AG	Backhoes on platform	OH crane	3	0.09	8	3.28	0	0	0	0	1	0.41	3.78	Dump into a box.
	17	AG	OHcrane	OHcrane	3	0.09	7	2.87	0	0	2	0.3	1	0.41	3.67	Dump into a box.
	18	BG	Shovel	OHcrane	—	—	—	—	—	—	—	—	—	—	—	Involves moving a building that is half the size of the pit.
	19	BG	FEL and backhoe combination	OHcrane	—	—	—	—	—	—	—	—	—	—	—	

AG = above ground
BG = below ground
FEL = front-end loader
FL = forklift
OH = overhead

Results of the subteam evaluation were presented to ensure agreement on the decisions. During this discussion, the group eliminated four of the remaining options, deciding they were feasible but much less promising than the remaining options. The VE session group scored the remaining 15 system options against the evaluation criteria. The results are included in Table 3.

2.4.4 Engineering Design Team Final Selection of Processes

2.4.4.1 Initial Value Engineering Options. From Table 3, the option scores from the VE session ranged from 2.59 to 8.36. The four top-scoring VE options are listed below:

- **Option 1—Score 7.74:** Above-grade retrieval in a large, open, primary and secondary confinement structure using a backhoe to excavate and either a forklift or overhead crane to transport waste to the characterization area.

- **Option 4—Score 8.36:** Below-grade retrieval in a large, open, primary and secondary confinement structure using an FEL to excavate and transport waste to the characterization area.

- **Option 8—Score 7.35:** Below-grade retrieval in a large primary confinement structure with moveable walls using an FEL to excavate and transport waste to the characterization area.

- **Option 9—Score 7.44:** Above-grade retrieval in a large primary confinement structure with two permanent walls segmenting the pit into three areas or cells. A backhoe is selected to excavate the waste and either a forklift or overhead crane is selected to transport waste to the characterization area.

The design team then performed more detailed evaluation of these options at the start of the preconceptual design. Through this more detailed evaluation, it was determined that options using segmented work cells (e.g., VE Option 9) faced considerable difficulties operating in the limited operating space. For VE Option 9, moving the equipment to the next walled-off area, while excavating the waste, proved to be a difficult operation. For these reasons, VE Option 9 was eliminated from hrther consideration by the design team.

Moveable walls (included in VE Option 8) were also eliminated as an independent design option and instead are to be considered a design feature that could be used with any option. In addition, hrther evaluation showed that the choice between a forklift and an overhead crane for transporting the waste had a more significant impact on design of the equipment and facility than anticipated in the VE sessions. Therefore, VE Option 1 was split into two separate options—one using an overhead crane and one using a forklift to transport the waste.

2.4.4.2 Final Value Engineering Options. This evaluation by the design team after the VE sessions resulted in three final options to be carried into the next phase of the project. These options are listed below:

- **Option I—Backhoe and crane method:** This option uses a backhoe to excavate the pit and an overhead crane to transport excavated material

- **Option 2—Backhoe and FEL method:** This option uses a backhoe to excavate the overburden and underburden and an FEL to excavate the waste zone (the FEL transports the excavated material)

- **Option 3—Backhoe and forklift method:** This option uses a backhoe to excavate the pit and a forklift and AGV combination to transport the excavated material.

2.5 Explanation of Results

Selecting three options for hrther evaluation in the next phase of the project involved many decisions about equipment types and facility configurations that benefit from hrther explanation. The Pit 9 Remediation Project Work Package Plan (WBS: C.1.01.07.04.05.01) lists three preconceptual designs to be included in the alternative selection process. Below is a discussion of how these options were evaluated and reasons parts of these options were eliminated from hrther consideration during this phase of the project. Other technical decisions on equipment and facilities also are discussed.

Primary advantages currently identified for each of the three options are discussed below:

- **Option 1**

  - Operating a backhoe from above the waste zone and using an overhead crane to transport waste reduces the potential for spreading contamination from driving equipment on contaminated waste or underburden. This option provides the least potential for dust generation and contamination spread by the excavating and transport equipment.

  - Entering the pit from the side or end, or ramping through the pit waste, is not required with a backhoe from above grade.

  - With above-grade excavation, requirements for preparing the pit floor are reduced to those needed for returning waste to the pit.

  - Using an overhead crane to transport waste boxes to and from the excavation area simplifies the method of returning waste to the pit. In the other options, a ramp must be built for mobile equipment to return to the bottom of the pit with the waste.

- **Option 2**

  - This option allows a simpler, more easily decontaminable confinement structure. Without a crane, D&D&D efforts are greatly simplified. With this option, the design objective is to maintain the shortest, simplest, primary confinement structure.

  - The mobile equipment can be decontaminated, as practical, then driven into a transport container to be taken to another waste pit or to disposal. Without cranes, the designs are much more flexible to be used at other TRU pits and trenches, as is required for this system.

  - An FEL can use a significantly larger bucket than a backhoe. Up to a 7.7-yd^3 bucket can be used with the FEL, and a 1.3-yd^3 bucket is the largest backhoe bucket listed in literature.

  - The larger FEL bucket provides the ability to remove objects as large as a 4 x 4 x 8-ft box without breaking apart the objects.

  - The larger FEL bucket provides the most undisturbed waste form practical to characterization. Larger loads are taken with each scoop, and each scoop can be delivered directly to characterization without dumping into boxes. This direct dumping method reduces waste mixing before characterization, which should also reduce the spread of contamination to other waste that may not have required treatment until mixed.

- The large FEL bucket delivers significantly more waste per load, thus reducing operating time.

- Using the FEL to transport waste eliminates additional dust generation and contamination spread that would otherwise occur by dumping pit material into boxes.

- **Option 3**

  - Option 3 has primarily the same advantages as Option 1. The difference between Options 1 and 3 is the use of a forklift instead of a crane to transport waste.

  - By using mobile equipment instead of an overhead crane to transport waste, the facility is shorter than Option 1, simplifying the ventilation equipment.

  - The shorter, simpler confinement facility needed for this option also reduces D&D&D costs; D&D&D of a crane from the Option 1 type of facility is considered relatively complex and expensive.

  - Without cranes, the designs are much more flexible for use at other TRU pits and trenches, as is required for this system. Mobile equipment can be decontaminated, as practical, then driven into a transport container to be taken to another waste pit or to disposal.

2.5.1 Work Package Plan Alternatives

The retrieval alternatives portion of the FY 2003 Pit 9 Remediation Project Work Package Plan are repeated below. Ties to the current options are identified, with explanation for deviations or eliminations.

1. **Plan description:** "Side or end entry into the pit, a roof structure over the entire pit providing confinement(s), moveable walls within the pit to define a work zone, excavation equipment for retrieval of waste. . ."

   This alternative is essentially the same as Option 2, the FEL method. Because of the close proximity of other waste pits, complete side entry may not be feasible, and the use of ramps is considered likely. Some facility height is needed for auxiliary equipment and operations such as delivering the waste to characterization, but the height is minimized. A moveable wall feature may be considered during conceptual design.

2. **Plan description:** "Surface entry into the pit, a building covering the entire pit providing confinement(s), moveable walls within the structure to define a work zone, excavation equipment for retrieval of waste. . ."

   This alternative is essentially the same as Options 1 and 3. Again, moveable walls may be considered during conceptual design.

3. **Plan description:** "Surface entry into the pit, a moveable building over the pit providing confinement(s), excavation equipment for retrieval of waste. . ."

   Movable buildings were identified in the work package for evaluation due to potentially decreased construction time, reduced D&D&D costs, and building reuse on another pit. The design team and VE session group both identified significant implementability issues and risks to the schedule. Scores on the options involving moveable buildings were significantly lower than on options with stationary buildings.

Some issues that outweighed potential benefits of moveable buildings included the following:

a. Decontamination or fixing the contaminants would be required between moves. This effort would be expensive, time consuming, and expected to outweigh potential savings in final D&D&D costs.

b. The risk exists for a potential release to the environment at any of the sealing systems or during a building move.

c. Each time the structure would be moved, an extensive effort would be required to prove confinement was intact and safe operations could restart. An operational readiness review may be required each time the facility is moved.

d. Moving the structure would be difficult and could potentially damage equipment and structures. This operation increases the risks to cost, schedule, and safety.

e. **A** moveable structure would require technically complex equipment (e.g., moveable ventilation ducts, disconnecting and reconnecting ducts, or portable ventilation and filtration systems). This complexity increases the risks to cost, schedule, and safety.

f. Equipment choices for a small, moveable building are limited to small, mobile excavating equipment and crane-mounted equipment. Small, mobile equipment does not have the reach or capacity to meet necessary production rates. With equipment sized large enough to be practical for this retrieval operation, the facility is nearly the size needed to cover the entire pit. Crane-mounted equipment was determined to be less appropriate than mobile equipment, as discussed in the following sections.

2.5.2 Mobile Equipment vs. Crane-Mounted Equipment

Crane-mounted excavation equipment designs (e.g., a backhoe arm mounted on a crane) were considered during this evaluation. The largest advantage of crane-mounted excavation equipment is the ability to retrieve waste without driving vehicles on the soil or waste. However, several design and operational issues were identified that reduced the evaluation scores of crane-mounted excavation equipment. These issues are listed below:

1. Crane-mounted excavation equipment would require a deep-span crane. Torsion loads on the girder and the approximate 37-m (120-ft) span are significant, and early calculations show a minimum required girder height of 3 to 4.6 m (10 to 15 ft). This additional height adds to the facility height, and therefore, the ventilation requirements and facility D&D&D costs.

2. **A** large crane in this type of primary confinement structure will require significant additional D&D&D effort and cost.

3. To gain contamination-control advantages of overhead cranes, either all waste-retrieval hnctions must be deployed from a single crane or multiple cranes must be used, as discussed below:

   a. Multiple cranes would increase the complexity of system design, increase the length of the confinement facility, and increase D&D&D costs.

   b. With all waste-retrieval hnctions deployed from one crane, retrieval becomes a serial operation with little or no parallel activities being performed. This reduces operational flexibility of the system, which is an important consideration to cost and schedule for both the retrieval process and the characterization and treatment process.

c. The ability to provide redundancy of hnctions for the system reliability required for this type of operation is much more difficult with crane-mounted equipment. The drive for reliability could result in multiple cranes, which would add to the length of the facility and facility and equipment D&D&D costs.

4. A crane is not as flexible for use in other pits and trenches in the SDA that may require retrieval

5. This option would require a new, specialized design with increased technical complexity (e.g., mounting an excavator arm to a crane trolley, designing and implementing remote operations capability, and managing hoses and cables). This design and subsequent operational testing would add schedule and cost risks to the project.

2.5.3 Mobile Excavating Equipment vs. Other Mining Equipment

Several types of mining equipment were evaluated during the technology-search phase of the project. These included technologies not generally considered for TRU waste-pit retrieval (e.g., draglines and rotating earth cutters).

A mining engineering consultant, experienced in the design and operation of mining equipment, was hired to perform this initial evaluation of mining-type excavation equipment. The evaluation is documented in EDF-4025 and shows initial ratings for the technologies and issues with the technologies.

The Pit 9 retrieval process is to be a balance between high-production rates and slow, careful movements that minimize dust generation, contamination spread, and mixing of the waste. Generally, mining equipment (e.g., draglines and rotating earth cutters) is designed for high-production-rate operations. Disadvantages of these types of mining equipment include the following:

- Too large for pits such as Pit 9 operations
- Too awkward for excavating in corners, around large objects, and at pit boundaries
- Extensive mixing of the retrieved materials
- Excessive dust generation.

2.5.4 Smaller Primary Confinement Structures and Segmented Areas

Smaller primary confinement structures that would not completely cover Pit 9 were evaluated because of their potential for reuse, reduction of D&D&D-phase operations, overall costs, and the amount of secondary waste generation. During the evaluation process, it was determined that operations became more constrained and increasingly difficult as the confinement structure size was reduced. Smaller and smaller equipment was required as the building size decreased. Issues then changed from mobility to adequate reach and capacity. Smaller confinements also require that the confinement is required to be moved or several confinements built and demolished. The issues that movable confinements present were previously discussed in Section 2.5.1. Consequently, implementing confinements smaller than 0.2 ha (1/2 acre) were considered a high-risk operation and potentially unfeasible.

Another confinement facility alternative considered was segmenting the confinement building and pit into separate sealed cells with hard walls and sheet piles beneath the walls into the pit. This approach to the facility design had the potential to provide more flexibility in retrieval and D&D&D operations. For example, during excavation in the second cell, operations to decontaminate and fix contaminants in the first cell could begin. Because airborne contamination levels are expected to be highest during excavation and dumping operations, this would isolate the first cell from this contamination. The air in the first cell would clear, and operations to decontaminate and fix contaminants could begin. This would allow much earlier manned entry into the facility. However, after hrther review of retrieval processes and equipment designs, it became apparent that there would be considerable difficulties operating in the limited space and in moving the excavating equipment to the next walled-off area.

Moving equipment from one cell to another required passageways into and out of each cell. This design feature increased the system complexity and decontamination issues associated with the large openings, pushing the small cell concept into a high design and operational risk.

3. CONCLUSION

This report presents a summary of the technology down-selection process used in the selection of three retrieval options for the Pit 9 Remediation Project. This is the first phase of several scheduled for the final selection. The first phase encompassed recognizing all the options available for satisfactorily retrieving the waste materials in Pit 9. The retrieval methodology was presented and selection was based on limiting cross contamination and contamination spread, implementability, and schedule.

The down-selection process resulted in selecting three options:

1. Backhoe/crane method
2. Backhoe/FEL Method
3. Backhoe/forklift method.

Preconceptual feasibility designs will be generated for these three options for Pit 9 and will comprise the basis for the final down-select process to a single recommended option. The recommended option will then be hrther developed during the conceptual design effort.

4. REFERENCES

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